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	Subsystem/Office Calorimeter Subsystem	
Document Title **Calorimeter Performance Acceptance Standards and Tests**		

Gamma-ray Large Area Space Telescope (GLAST)

Large Area Telescope (LAT)

Calorimeter Performance Acceptance Standards and Tests

DOCUMENT APPROVAL

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CHANGE HISTORY LOG

Revision	Effective Date	Description of Changes

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1 Purpose

This document summarizes the level of performance various components of the calorimeter must reach to be acceptable for next stage of integration.

2 Scope

The standards defined in this document are not the only requirements on these components. They are only the performance standards affecting the scientific performance of the instrument. Separate documents address mechanical, electrical, environmental and other standards that these components must meet.

3 Definitions

3.1 Acronyms

AFEE – Analog Front End Electronics Board

GCFE – Glast Calorimeter Front End ASIC

GCRC – Glast Calorimeter Readout Controller (digital ASIC)

GLAST – Gamma-ray Large Area Space Telescope

LAT – Large Area Telescope

TBR – To Be Resolved

CAL – Calorimeter Detector

TRG – L1 Trigger

TEM – Tower Electronics Module

3.2 Definitions

μsec, μs – Microsecond, 10^{-6} second

Dead Time – Time during which the instrument does not sense and/or record gamma ray events during normal operations..

s, sec – seconds

4 Applicable Documents

Documents that are relevant to the development of the GCFE concept and its requirements include the following:

GLAST00010, “GLAST Science Requirements Document”, P.Michelson and N.Gehrels, eds., July 9, 1999.

LAT-SP-00010, “GLAST LAT Performance Specification”, August 2000

LAT-SS-00018, “LAT CAL Subsystem Specification – Level III Specification”

LAT-SS-00210, “LAT CAL Subsystem Specification – Level IV Specification”

LAT-SS-00088, “Calorimeter Front End ASIC- Conceptual Design”

LAT-DS-00085, “Calorimeter CsI Crystal Specification”

LAT-DS-00072, “Specification for the Calorimeter PIN photodiode Assembly”

5 Introduction

The *GLAST* calorimeter sub-system consists of many parts that are assembled and tested in different laboratories and facilities. All these sub-assemblies need to be tested before shipping to NRL to be assembled into a calorimeter module, which then itself is shipped to SLAC for integration into the LAT. Besides mechanical , electrical, environmetal, Quality Assurance, and any other applicable standards, there are "scientific performance standards that must be met. This document addresses these scientific standards for the various sub-assemblies where such standards apply and how they are tested. To the extent that these issues are addressed in the sub-assembly documents, the sub-assembly documents shall prevail. To the extent they are not addressed in the sub-assembly document, this document shall defined the scientific performance standards.

6 Crystal Performance Acceptance Standards

The crystal acceptance standards and method of measurement are defined in the crystal specifications document LAT-DS-00095-03, "Calorimeter CsI Crystal Specification".

7 Diode Performance Acceptance Standards

The diode acceptance standards and methods are defined in the diodes specifications document LAT-DS-00072-002, "Specification for the Calorimeter PIN photodiode Assembly (EM parts document number)".

8 CDE Performance Acceptance Standards

The CDE acceptance standards and methods are defined in document XXX.

9 PEM Performance Acceptance Standards

A PEM will be considered to have acceptable performance if:

- All 96 x 2 crystal ends collect at least 5000 electrons per MeV in the large PIN diode for energy deposited in the middle of the crystal. This measurement will be executed using cosmic ray muons. The center of the crystal is considered to be the central two twelfths of the crystal.
- All 96x2 crystal ends collect at least 800 electrons per MeV in the small PIN diode for energy deposited in the middle of the crystal. The center of the crystal is considered to be the central two twelfths of the crystal.
- The light tapering of all crystal within a PEM, i.e. the ratio of light collected from the far end over the light collected at the near end of a crystal, is between 0.40 and 0.75. This tapering must be for both large and small PIN diodes. This measurement will be executed using cosmic ray muons. The ends of the crystal are considered to be the extreme twelfths of the crystal.
- The absolute light yield from all crystals in a module will be within plus or minus fifteen percent of the mean.

These measurements are to be performed with the assistance of an external muon telescope and with laboratory readout electronics. The laboratory electronics should have sufficiently low noise preamplifiers and sufficiently understood offsets and non-linearity in the electronics to not affect the measurements with muons. The amplifier shaping time will be set to match the flight AFEE ASIC designed by SLAC. The laboratory system's gain will be calibrated using both external capacitors and the peak of the Landau distribution of energies deposited by cosmic ray muons. If these values disagree by more than 10%, the system will be considered un-calibrated. If the values agree to within 10%, the average of these two values will be considered the nominal gain of the system.

10 Calorimeter Front End ASIC (GCFE) Performance Acceptance Standards

The GLAST Calorimeter Front End ASIC (GCFE) performance and acceptance tests are defined in document XXX.

11 Calorimeter Readout Controller (GCRC) Performance Acceptance Standards

The GLAST Calorimeter Readout Controller digital ASIC (GCRC) performance and acceptance tests are defined in document XXX.

12 Calorimeter Analog Front End Electronics (AFEE) Board Performance Acceptance Standards

The GLAST calorimeter Analog Front End Electronics board (AFEE) performance and acceptance tests are defined in document XXX.

13 Calorimeter Tower Electronics Module (TEM) Performance Acceptance Standards

The GLAST Calorimeter Tower Electronics Module (TEM) performance and acceptance tests are defined in document XXX.

14 CAL Module Performance Acceptance Standards

A CAL module will be considered to have acceptable performance if:

1. All 96 x 2 crystal ends collect at least 5000 electrons per MeV in the large PIN diode for energy deposited in the middle of the crystal. This measurement will be executed using cosmic ray muons. The internal GCFE pulser and the peak of the Landau distribution of energies deposited by cosmic ray muons in each crystal will be used to calibrate the LEX8 and LEX1 channels. The center of the crystal is considered to be the central two twelfths of the crystal.
2. All 96x2 crystal ends collect at least 800 electrons per MeV in the small PIN diode for energy deposited in the middle of the crystal. The center of the crystal is considered to be the central two twelfths of the crystal. The internal GCFE pulser and the peak of the Landau distribution of energies deposited by cosmic ray muons in each crystal will be used to calibrate the HEX8 range and to cross-calibrate with the LE range muon calibration. The HEX1 range will be cross calibrated from the HEX8 range using the internal pulser.
3. The light tapering of all crystal within a PEM, i.e. the ratio of light collected from the far end over the light collected at the near end of a crystal, is between 0.40 and 0.75. This tapering must be for both large and small PIN diodes. This measurement will be executed using cosmic ray muons. The ends of the crystal are considered to be the extreme twelfths of the crystal. This measurement will be done with the LEX8 signals.
4. The absolute light yield from all crystals in a module will be within plus or minus fifteen percent of the mean. This measurement will be done with the LEX8 signals.
5. The high gain low energy range (LEX8) shall be operational at least over the range covering from 2 MeV to 200 MeV for all 96x2 crystal ends. The calibration used to determine the range of operability is derived in step 1 above.
6. The low gain low energy range (LEX1) shall be operational at least over the range covering from 5 MeV to 1600 MeV for all 96x2 crystal ends. The calibration used to determine the range of operability is derived in step 1 above.
7. The high gain high energy range (HEX8) shall be operational at least over the range covering from 100 MeV to 12000 MeV for all 96x2 crystal ends. The calibration used to determine the range of operability is derived in step 2 above.
8. The low gain high energy range (HEX1) shall be operational at least over the range covering from 500 MeV to 100 000 MeV for all 96x2 crystal ends. The calibration used to determine the range of operability is derived in step 2 above.
9. The noise in the LEX8 range will be less than 3000 electrons (RMS) over the range covering from 2 MeV to 200 MeV for all 96x2 crystal ends. The noise level is determined by measuring the width of the distribution of a collection of pulser signals.
10. The noise in the LEX1 range will be less than 3500 electrons (RMS) over the range covering from 5 MeV to 1600 MeV for all 96x2 crystal ends. The noise level is determined by measuring the width of the distribution of a collection of pulser signals.
11. The noise in the HEX8 range will be less than 5000 electrons (RMS) over the range covering from 100 MeV to 12000 MeV for all 96x2 crystal ends. The noise level is determined by measuring the width of the distribution of a collection of pulser signals.
12. The noise in the HEX1 range will be less than 5000 (RMS) electrons over the range covering from 500 MeV to 100 000 MeV for all 96x2 crystal ends. The noise level is determined by measuring the width of the distribution of a collection of pulser signals.

13. All discriminators on all 96x2 crystal ends are functional and each bit (not bit pattern) will have been tested. Bit patterns can be tested on all crystal ends simultaneously, but not more than half the crystal ends on a board layer shall have the same value.
14. All DACs are functional for all 96x2 crystal ends and each bit (not bit pattern) will have been tested. Bit patterns can be tested on all crystal ends simultaneously, but not more than half the crystal ends on a board layer shall have the same value.
15. All readout modes will have been tested on all 96x2 crystal ends. Each readout mode will be tested with all crystal ends on a board being in the same mode. Each pair of compatible readout modes will also be tested simultaneously on each board.
16. The auto-ranging will have been demonstrated to switch between all 4 ranges with pulser signals on all 96x2 crystal ends. The auto-ranging can be tested on all crystal ends simultaneously, but not more than half the crystal ends on a board layer shall have the same range being tested.
17. The rate counters shall be demonstrated to count up to 16 bits and at speeds up to 10 kHz. They shall also be demonstrated to keep the correct count up to 1 Khz. This shall be demonstrated with pulser signals and by adjusting the discriminator levels.
18. The TEM shall be demonstrated to operate at speeds up to 10 kHz. This shall be demonstrated by a combination of internal and external pulsers.
19. All valid commands to the TEM shall be tested. All address, function, and data bits shall be tested. Each valid bit within an address, function and or data block shall be tested separately, although address, function and data bits can be tested simultaneously.